Agriculture, Risk and Climate Change

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Climate modelers have been warning for a decade about the extent and seriousness of global climate change, brought about by increasing greenhouse gas emissions over the past century. Some skeptics have questioned the validity of the assumptions underpinning these models, but climatologists have adjusted the models only to conclude that climate change may be greater in magnitude than previously expected. Most recently, inclusion into the models of methane emissions from melting permafrost is shown to bring about a positive feedback in the earth's climate system (Semiletov et al 2004). Recent models with strong carbon cycle feedback have predicted average temperature increases of 6-7^{o}C, up from previous estimates of 3-4^{o}C, (Jones et al 2003). Today, many skeptics have been silenced by climate data showing the past decade to have been the warmest in recorded history, and according to other sources the warmest in the last 1,000 years (Osborn and Briffa 2005).

There is now less skepticism over the reality of climate change and more discussion on how it will impact the earth's systems and the world's population, and what can be done about it. The term "global warming," popularized by the world's media looking for a sound-bite, does not accurately reflect the reality of climate change. It involves a general trend of temperature increase across the globe, but also entails fundamental changes in weather patterns, including changes in the persistence and magnitude of El Niño events, hurricanes, floods, and droughts, as well as fundamental changes in everyday rainfall patterns.

As far as agriculture is concerned, despite some projected increase in photosynthesis brought about by the increased concentrations in CO_2 (Long et al. 2006), the changes in temperature will have a far greater detrimental effect, resulting in a general trend of reduction in productivity, although it is important to note that, for some regions and crops, opportunities for increased production will exist. Jones and Thornton (2002, 2003) predicted climate change to reduce maize productivity by 10%. The studies showed three distinct local response patterns:

1. The crop benefits from climate change.
2. Minor reductions in yield occur.
3. Devastating crop losses ensue.

The first case was restricted mainly to highland areas, where increasing temperatures, and in some cases better rainfall, benefited maize. These areas were not extensive and the important response here should be to capitalize as much as possible by choosing varieties that maximize the benefits of the change. The second case is widespread, and solutions should lie in plant breeding and sound agronomic management. Heat and drought tolerance will be the key parameters here. The third case is a worst-case scenario and unfortunately could be widespread. Major modifications to the agricultural system would be necessary, even to the extent of population migration.

The most troubling finding of these studies was that these three response patterns are highly localized. Drastically different responses can occur within a few kilometers of one another. Recommendations for adaptation to climate change cannot, therefore, be regional and must be made locally specific. Smit and Skinner (2002) have shown that much can be done by using farmers' knowledge of variation in the past to adapt to future extreme events. This indeed is how climate change will be experienced—not as a gradual process, but as a change in the frequency of extreme events.

Climate change is also likely to impact on agricultural genetic resources. For example, impacts on the distributions of crop wild relatives (themselves bearers of genes potentially critical for adaptation) are predicted to be significant, with 18% of species in important crop genepools likely to become extinct by 2050 (Lane et al. in press). Additionally, farmers may drop traditional landraces no longer adapted to the local climate, resulting in genetic erosion and a lowering of the diversity in crop genepools.

These and other impact studies provide scenarios for disaster in agricultural systems. Research must now concentrate on how poor farmers can adapt to change. Agriculture without the threat of global climate change is inherently risky, and so only increases the risk for farmers, potentially knocking back hard won gains over the past years. However, as shown in some of the impact studies, global climate change is partly predictable; therefore, the research challenge is to find means of managing that risk. To be successful, adaptation strategies must be put in place at a rate equal to or greater than the rate of change in climate.

Some of the major challenges come from the likely greater prevalence of drought and floods. In many cases, these weather patterns will be new in the farmers' experience. Therefore, a key research theme must be the development of risk avoidance strategies, which are still deficient under current circumstances, but will be critical if poor farmers are to manage local changes in climate.

A core research area for the CGIAR is the development of improved germplasm. In order to adapt to climate change, many regions will need crops with greater resistance to drought. Unfortunately, plant breeding takes time, so needs for improved germplasm must be identified now in order to plan for the future. In the case of drought tolerance in beans, *Phaseolus vulgaris* (L), CIAT identified the demand almost 25 years ago, and many CIAT scientists have played key roles in the development of new varieties. Beebe (2006) produced commercial varieties that yield up to 800 kg per hectare in drought situations, where local varieties would yield almost nothing. Plant breeding is a lengthy process, but remains a cost-effective way of getting stress-tolerant materials into the hands of smallholder farmers.

As for adaptation mechanisms employed by the farmer, informal risk avoidance strategies are common. Using little or no inputs is a common choice, but this restricts yields in the absence of stress. Borrowing money from family or local money lenders is another common tide over, but sale of livestock, house and farm are also common results. In the event of widespread crop failure, this strategy is not sustainable. Livestock is also used as a risk avoidance strategy in many regions, whereby the sale of livestock when a farmer’s crops fail can generate the income to feed the family, but under widespread drought there is little capital available for buying livestock and farmers are forced to sell at a very low price. Diversification is also a valid risk avoidance strategy already used by many farmers, which certainly puts poor farmers in a better position to cope with climate change. One problem associated with many of these risk avoidance strategies is that they generally aim to lower the exposure to risk, but in so doing limit potential and have considerable opportunity costs. They often tend to hinder the efforts of poor smallholders to break out of poverty.

One concrete example in which innovation may provide farmers with a robust risk avoidance strategy that optimizes the opportunities is through weather insurance. When dealing with poor smallholder farmers, there is a distinct lack of long-term reliable data for the productivity of staple crops or of crop failure. In the absence of these data, it is difficult to design appropriate insurance instruments. However, the recent revolution in the availability of data on climate and weather across the tropics, coupled with the generation of better predictive weather models, permits the development of scientifically sound insurance schemes under which the risks for both the farmer and insurer are manageable. Diaz Nieto et al. (2006) have recently developed robust methodologies for developing prototype insurance schemes for drought, which can be tacked onto micro-credit finance, with the aim of ensuring farmers make the optimal choices when confronting climatic risk. Under future climate change, this may be an important mechanism for helping farmers face risk.

Another means of looking at climate change is by considering that in many cases the future climate for a specific site already exists in another part of the globe. Based on this, many local adaptations can be achieved through the transfer of technologies or practices from one region to another. The Homologue tool (Jones et al. 2005) does just this, identifying sites with similar climatic characteristics. When coupled with scenarios for global climate change, predicted future climates for a given site can be found today in another part of the globe. An example of this is the future climate of Manaus, identified to exist today in Vichada in Colombia. Transfer of technologies from one site to the next can provide farmers with the means of adapting to change, taking advantage of existing experiences.

With the true extent, magnitude and impact of climate change on agricultural systems still not fully understood, innovations today so that farmers can better avoid risk today will stand them in good stead for the uncertain tomorrow. Given the local-scale heterogeneity in predicted climate change impacts, the research challenges lie in ensuring that the most appropriate technologies, practices and risk-avoidance strategies get to the individual farmers.

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